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Role of the inland waterways system during mobilization

Kertz, Gary W.

Monterey, California. Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL
Monterey, California

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ROLE OF THE INLAND WATERWAYS SYSTEM DURING MOBILIZATION

by

Gary W. Kertz

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Role of the Inland Waterways System During Mobilization

by

Gary W. Kertz
Lieutenant Commander, United States Navy
B.S., Sam Houston State University, 1969

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of the requirements for the degree of

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December 1991

ABSTRACT

This thesis examines the Department of Defense's (DOD) use of the inland waterways system during mobilization. The study furnishes a historical and present-day review of the inland waterways system. The thesis also addresses the military's current use of the inland waterways system. The emphasis of the thesis is on exploring the potential cost savings available in using inland waterway transportation for unit movements. There is potential for the military to realize sizable cost savings by moving unit equipment over the inland waterways. The paper proposes that DOD planners use Gulf coast ports as points of entry for returning equipment. These Roll-on/Roll-off (RO/RO) capable ports can provide low-cost waterborne transport when moving military units returning from overseas deployment.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

An efficient and effective transportation system is vital to national defense. The ability to transport troops, equipment, and material quickly and to mobilize and sustain industrial power is essential in war. [Ref.1:p.4] During mobilization, the United States Department of Defense (DOD) depends upon railroads and motor carriers to provide rapid transport for troops and equipment. Rail and truck modes move troops and equipment from home bases in the continental United States (CONUS) to departure ports and airfields. From ports of embarkation (POE), airlift and sealift forces move troops, arms, and equipment to the overseas sites of operations. During this first phase of mobilization, the nation's transportation system must move troops and equipment quickly. [Ref.2:pp.3-6]

The second phase of mobilization is sustainment. The sustainment phase requires the DOD transportation system to move troops, equipment, and arms to the projected force until no longer required by the mission. Sustainment also involves the movement of raw materials to the nation's industrial base. For this phase of mobilization, DOD transportation planning depends heavily upon inland navigation to move the raw materials necessary to support the industrial base.

During World War II, the inland navigation system proved to be an important strategic resource. The inland waterways were instrumental in

the home front industrial mobilization effort. The inland waterways made up the essential link in the petroleum transportation network. Barges also moved other strategic raw materials. In addition, inland rivers provided a thoroughfare for military vessels built at inland shipyards. [Ref.3:pp.17-18]

Since World War II, the military has continued to use the inland waterways for the movement of bulk petroleum products. Today 95 percent of the total cargo moved on the inland waterways by the DOD consists of bulk petroleum products. [Ref.4:p.6] Military interest in the inland waterways for other uses, including unit movements, has been low. Traditionally, military transportation officers have selected motor and rail carriers for the movement of finished goods and unit equipment.

In 1986, the Army National Guard and the Army Corps of Engineers completed several test movements of unit equipment using the inland navigation system. These successful movements showed substantial transportation savings and generated increased interest by the military in the use of the inland waterway system.

B. STATEMENT OF THE PROBLEM

In recent years, inland waterway transportation has become increasingly important to the Department of Defense. This study evaluates the inland waterway system's potential during national mobilization.

The United States is a large, diverse land area intersected by streams, rivers, and bays. When Europeans began exploration of this land, they found more than three million square miles of untamed wilderness. To civilize such a large area meant that transportation had to become a

leading industry of the nation. [Ref.1:p.16] Overland travel was slow on the roads of colonial America. It was often easier to use water transportation. Water carriage developed into the main type of domestic transportation for many decades. Chapter II chronicles the development of this transportation mode. The chapter also explores the inland waterways' impacts on American life, including the military.

If mobilized, the nation would depend on the inland waterways to transport the bulk war materials necessary for defense. Chapter III describes the physical inland waterway system that these bulk commodities would move over. In addition, Chapter III profiles the equipment and facilities of the inland navigation industry. The chapter also gauges the adequacy of the inland navigation system to support national defense mobilization efforts.

Recent movements by Army units on the inland waterway system have shown sizable cost savings while providing training on a new transportation mode. Chapter IV examines these movements to consider those aspects of inland navigation transportation that have the potential to benefit the military.

Chapter V presents conclusions and recommendations which includes a discussion of the contributions of the inland waterways during mobilization.

C. SCOPE

The Mississippi River System dominates the nation's inland waterway navigation system. The Mississippi River System, when combined with the Gulf-Intracoastal Waterway, provides waterborne commerce to the heartland

of the nation. [Ref.5:p.1] Most of the recent waterborne military unit movements have occurred on these two waterway systems. This study of the military's use of inland navigation focuses on the Mississippi River System and the Gulf-Intracoastal Waterway.

II. HISTORY OF THE INLAND WATERWAYS SYSTEM

A. HISTORICAL BACKGROUND

From the days of the earliest settlements, the abundance of natural waterways in North America have played an important role in the development of this nation [Ref.6:p.9]. This chapter will provide a brief survey of the traffic that has travelled over the inland waterways. The purpose of this historical review is to provide a foundation for future chapters that will explore the military potential of the inland waterways. This chapter will examine three periods in the development of the waterways and explore both civilian and military influences.

1. The First Period: 1620 - 1865

The first period began in the early seventeenth century with the use of natural waterways as passageways of exploration. Later, the rivers served as highways of settlement since people could only penetrate the interior where rivers made it possible. [Ref.6:p.9] The few roads built during the colonial period were mainly large cleared paths with surfaces of beaten earth, planks, or broken stone [Ref.7:p.86]. One famous road of the period was the Wilderness Road. This heavily travelled road ran from Virginia southwest through the Cumberland Gap, but it was not made passable for wheeled traffic until the 1790s. [Ref.7:p.85]

> "The new nation found itself economically anchored to the coastal plain in its first decades of existence." [Ref.8:p.79]

As settlement gradually spread west and south from the East Coast, the question then became how to improve the transportation of commerce between

the different regions. The few major roads that existed were inadequate to move the crops of the western farmers and the industrial goods produced by the manufacturers in the East. [Ref.8:p.79]

Because of inadequate roads and expensive, inefficient freight-wagon transportation, western farmers lost twenty to fifty percent of the value of their crops while transporting them to their seaboard customers [Ref.8:p.80]. The need for more efficient methods of moving material led to a greater awareness of the nation's inland waterways and to the building of numerous canals. Between 1790 and 1860, more than 4,250 miles of hand-dug artificial waterways were constructed in America. [Ref.8:pp.81-90]

These canals led to significantly lowered transportation costs. Western farmers were able to dispose of their agriculture surplus at a greater profit while letting their eastern neighbors eat better for less. As a result, a greater portion of money was available to spend on non-food goods. [Ref.8:p.90] Real incomes in the West and in the East rose as a result of the canals. The expansion of productive transportation increased the economic activity in both regions. Canals promoted the growth of commercial farming and industrial activities, while developing the basis for the rapid growth of cities along their banks [Ref.9:p.247]. By connecting the East and West, the canals started a series of economic interactions that are still present today in the form of the national industrial economy [Ref.8:p.91].

Even while the canal building movement was at its height, the development of the steamboat was signalling the end of the canal building era. From the early 1800s to the Civil War, transportation on the

Mississippi, Missouri, and Ohio Rivers enjoyed significant growth during the period of the steamboats. The course of steamboat growth is shown in Table 1.

TABLE 1

NUMBER AND TONNAGE OF STEAMBOATS OPERATING ON THE WESTERN RIVERS 1817 - 1860

Year	Number	Tonnage
1817	17	3,260
1820	69	13,890
1823	75	12,501
1825	73	9,992
1830	187	29,481
1836	381	57,090
1840	536	83,592
1845	557	98,246
1850	740	141,834
1855	727	173,068
1860	735	162,735

Source: [Ref.10:p.33]

The Civil War marked the end of the first period of waterway transportation. The engaging armies moved along the rivers, burning or sinking hundreds of river vessels [Ref.8:p.283]. This conflict destroyed the freight and passenger traffic patterns that had been formed by steamboats before the war. When peace came, the pressure from the railroad competition was too much for a commercial rebirth on the inland waterways. [Ref.8:p.283]

In contrast to the inland waterways, the Civil War strengthened the railroads, excluding the southern railroads. War needs had created track expansion, increased efficiency in track construction, and new methods of

handling freight on trains. Wartime demands forced the change from iron to steel rails and caused a shift in fuel sources from wood to coal. [Ref.11:pp.62-63]

2. The Second Period: 1865 - 1890

The second period lasted about thirty years after the Civil War. During this time, the railroads became the clear leader in the competition for the domestic transportation market. The railroads made some gains as a result of abuses against the water carriers. The railroads purchased steamboat lines only to let the vessels sit at their moorings and rot. They also purchased steamboat lines and operated the boats at a loss to eliminate other steamboat lines. [Ref.8:p.284] However, history may more fairly credit the ascendancy of the railroads, at the expense of the inland waterways, to the competitive advantages of the railroads. The railroads offered year-round reliable service, whereas the waterways could not match the speed, frequency, and accessibility. The superior service of the railroad lines was not because of a desire to give the paying public maximum service, but inherent in the essential conditions under which railroads operated [Ref.10:p.501]. In contrast with the fierce competition that existed on the rivers between steamship lines, railroads had a virtual monopoly within the territories they served. For the small steamboat operators, it was imperative to get all the freight and passenger business available on any trip, even if it meant frequent delays. The railroads didn't have that problem. What one train left, the next train would pick up. In addition, the railroads could quickly adapt to freight volume by adding or dropping cars. Steamboats had to move a

fixed hull and superstructure through the water, whether the cargo was large or small. [Ref.10:pp.500-501]

Another advantage for the railroads was accessibility. Nature forced the inland waterway system to operate within a fixed trunk and branch network. To materially extend that range was slow and expensive, while the railroad network continued to expand at a rapid rate after the war. In the thirty years after the Civil War, track mileage grew from 30,000 miles in 1860 to 167,000 miles by 1890. [Ref.8:p.283]

The inland waterways entered a period of neglect after the Civil War. On the other hand, rail transportation continued its climb toward command of the dominant position in domestic transport for both freight and passenger movement. Yet, as commerce on the inland waterways declined, technical developments in marine engineering led to the development of screw propeller propulsion systems that were more efficient than the old sternwheel driven boats. The emergence of screw propeller boats and the adoption of towboats and barges to replace the packet steamships helped prepare for the third or modern period of the inland waterways. [Ref.3:p.6]

3. The Third Period: 1890 - Present

As the nation entered the last decade of the 19th century, farmers and merchants were tiring of railroad abuses, especially high rates [Ref.11:p.123].

> At the turn of the century Charles A. Prouty (1853-1921), member of the Interstate Commerce Commission, asked a railroad traffic official the basis on which his rates were made. The official replied: 'To be perfectly honest, we get all we can, and even that is too little.' [Ref.11:p.123]

Complaints against the railroads led to congressional interest in the inland waterways. Congress viewed the waterways as an inexpensive transportation alternative and as a way to control the railroads. "In 1907, President Roosevelt appointed the Inland Waterways Commission to study the needs and possibilities of the waterways." [Ref.8:p.286]

> All of this interest and enthusiasm bore fruit in the Panama Canal Act of 1912, the legislative keystone for the revival of inland transportation. The act decreed that railroads could not own, control, or operate a water carrier. [Ref.8:pp.286-287]

During World War I, the war's massive demands on the transportation system spurred a renewed interest in more effective use of the waterways. After World War I, the federal government provided additional support to water carriers by creating the Inland and Coastwise Waterways Service in 1918. [Ref.8:p.287] Congress then passed the Transportation Act of 1920 which declared the intent of Congress to promote, develop, and encourage water transportation in the United States [Ref.8:p.287].

This declaration of intent was given reality in 1924 when Congress created the Inland Waterways Corporation, (IWC). The IWC was a publicly owned corporation tasked to prove the transportation capabilities of modern towboats and barges by operating a federal barge line. [Ref.8:p.287] The corporation included five million dollars in capital stock investment held by the United States government. Control of the enterprise was given over to the United States Army Corps of Engineers (USACE). The USACE and the IWC undertook an orderly improvement of the nation's waterways to support modern navigation practices on the inland waterways. The IWC showed to the private sector the profitability of the inland waterways. From 1924 to 1938, the IWC made a net profit of $2.9

million. [Ref.3:p.5]. During the corporation's lifetime, the IWC made important advances in the development of modern towboats and barges and helped river communities build port terminals [Ref.3:p.6]. The success of the IWC and USACE from 1924 to 1940 was evident by the increase in tonnage moved on the inland waterways. In 1924, the inland waterways moved slightly more than 34 million short tons.[1] By 1940, the tonnage had increased to 70.2 million short tons. [Ref.8:p.287]

When the nation entered World War II, about 1,000 towboats and 5,000 barges plied the inland waterways. The war years reshaped and strengthened inland navigation. The mobilization effort opened new markets and traffic patterns for the inland waterway industry. Additionally, the contribution of the waterways during the war helped the inland waterway industry get Congressional approval for further navigation and harbor projects. The influx of federal dollars, coupled with the general boom of the post-war period, aided the continued growth of the inland waterway industry. [Ref.3:pp.8-22] The following chapter examines existing conditions and physical structures of the inland waterways.

B. MILITARY HISTORY OF THE INLAND WATERWAYS

The military used America's inland waterways to move men and equipment to some of the earliest conflicts fought on American shores. River transport of the military played a role during the French and Indian Wars and the American Revolutionary War. The rivers carried a variety of traffic ranging from scouting canoes to small supply sloops. However, it

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[1] A short ton equals 2,000 pounds.

wasn't until the successful introduction of steam power to water vessels that the waterway system provided the upstream capability needed by the military. Under the conditions of inland navigation, sail power was of limited value and the swift currents that supported downstream navigation could only be offset by human energy or, in some cases, horses to move men and equipment upstream. The successful introduction of the steamboat to the inland waterways in 1807 gave the military the ability to defy the currents with the resulting strategic and logistic mobility.

Five years after the introduction of steam to the inland waters, steamboats were transporting military stores. During the War of 1812, steamboats travelled from Pittsburgh to New Orleans in the support of General Jackson's defense of New Orleans. [Ref.10:p.551]

In the years preceding the Civil War, steamboat design and operation improved. The military increasingly used river transportation to carry troops and supplies to the remote army forts of the West. The Mississippi, Missouri, Arkansas, and Red Rivers had considerable troop and equipment movement to support combat operations against hostile Indians. [Ref.10:p.552] During the Mexican War, Army forts along the shores of the Ohio and Mississippi Rivers used steamboats to move troops, horses, and supplies to the point of embarkation at New Orleans [Ref.10:p.553].

1. The Civil War

The outbreak of the Civil War threatened to mark the end of steamboating as a business. [Ref.12:p.21] As the Civil War progressed, railroads became the method of choice for the movement of war material and personnel.

However, Northern armies found that the navigable tributaries of the Ohio and Mississippi River systems provided thoroughfares that led into the center of the Confederacy [Ref.10:p.554]. General Sherman wrote of another advantage to rivers. He stated that his forces could easily defend rivers because there were no bridges or rails for raiders to destroy.

> We are much obliged to the Tennessee which has favored us most opportunely, for I am never easy with a railroad which takes a whole army to guard, each foot of rail being essential to the whole; whereas they can't stop the Tennessee, and each boat can make its own game. [Ref.10:p.555]

Besides defense, the rivers were superior to the railroads in carrying capacity. Single-track rail lines could only accommodate a limited number of trains daily. [Ref.10:p.555] Plus, the construction and design of steamboats allowed the military to bring the boats ashore almost anywhere and disembark troops and horses. Where railroad and steamboat services were both available, lower steamboat costs prompted the use of the river. [Ref.10:p.555]

During the Civil War, the northern military found the inland waterway transportation to offer advantages of ample capacity and low cost. However, there were two disadvantages to the inland waterways. First, planners had to adapt logistic and operational plans to work around seasonal high and low water levels. The second disadvantage lay with the organization of service. The railroads offered large, established organizations that could meet the demands of the government in a systematic manner. The waterways' interests were numerous and could not provide a substantial, stable body for the government to negotiate contracts. [Ref.10:p.556]

2. World War I

During World War I, the inland waterways made two primary contributions to the war effort: the movement of bulk traffic consisting of coal, oil, iron, steel, sulfur, and limestone; and as the secondary mover for freight that rail would move under normal peacetime conditions.

By the fall of 1917, the nation was experiencing shortages of freight cars. East Coast ports had some 180,000 loaded freight cars at freight terminals while the national shortage of cars was 158,000. In December 1917, the government took control of the railroads in an attempt to break this jam of back-logged foodstuffs, armament, and military equipment. [Ref.11:pp.184-186] The government also turned to the rivers as a source of transportation help. At the request of the War Department, old wooden crafts were reconditioned and put back into service. The War Department also encouraged the building of new barges and towboats. The cost of a barge was less than the equivalent train of rail cars, and inland shipyards could build towboats as fast as the rail industry could build a locomotive. "Rounding up all the tonnage that would float, building new barges and towboats, merging local carriers into a transportation system, the government formed the Federal Barge Lines." [Ref.13:p.259] After the war, the Federal Barge Line became the Inland and Coastwise Waterways Service [Ref.3:p.4].

3. World War II

Shortly after the Japanese attack on the American fleet at Pearl Harbor, German submarines began destroying cargo ships off the Atlantic and Gulf Coasts. These high shipping losses in the early months of the

war required transferring material normally handled by coastwise shipping to protected inland waterways. This move was also influenced by the decision in early 1942 to assign all ocean tankers to convoy duty. [Ref.3:p.12]

Not only were defense transportation planners faced with trying to find ways of developing additional capacity, they also needed to develop new plans for commodity movement. The demands of war production and shipping threats forced changes within the transportation system. The railroads, motor carriers, and tow and barge industries were moving unfamiliar commodities between unfamiliar origin and destination points. [Ref.3:p.12] "The war upset the normal balance of distance, load, and back-haul." [Ref.3:p.12]

In the spring of 1942, an "energy crisis" developed on the East Coast. Most naval ships and almost all merchant ship convoys that were transporting material to the European theater bunkered on the East Coast. At the height of this crisis, the daily shortfall exceeded 175,000 barrels. The Office of Defense Transportation (ODT) turned to the inland waterways for the answer to this crisis. The waterways offered many advantages including cost and flexibility. The barge industry's nearest competitor, pipelines, charged 3.2 mills compared to 1.25 mills per ton mile for barge movement. The study showed that shifting oil to barges could be done quickly because operators could assemble tows piecemeal as equipment became available. The inland waterways provided needed flexibility in drop-off and pick-up points. Finally, the waterways industry could easily convert barges and towboats from war to peacetime use. Further analysis also indicated that the nation could save the same

types of costs by using the waterways to move other commodities in addition to petroleum. [Ref.3:pp.13-14]

The most significant contribution of the inland waterway system to the war effort was the movement of petroleum and petroleum products. The inland fleet moved 1.8 billion barrels during World War II. The average tow was 5,000 tons or roughly 125 freight cars. [Ref.3:p.14]

While petroleum and petroleum products made up most of the inland waterways contribution to the war effort, other strategic bulk materials moved on the waterways included coal and steel. In addition, the Mississippi River System also served as a conduit to the ocean for Army, Navy, and auxiliary vessels built at inland shipyards. Table 2 shows the breakdown of the almost four thousand vessels that floated down the Ohio and Mississippi Rivers during the war. [Ref.3:p.17]

TABLE 2

NAVAL CONSTRUCTION BY RIVER SHIPYARDS

Quantity	Type	Location
180	LST's	Ohio River Yards
124	LST's	Illinois River Yards
17	AOG Navy Tankers	Savage Minnesota on the Mississippi River
13	Army Supply Ships	Tennessee River
12	Destroyer Escorts	Ohio River Yards
3	Tugboats	St. Louis
4	ATL's	Neville Island Shipyard Pittsburg, Pennsylvania

Note: There were also 17 destroyer escorts and a number of submarines built at Great Lakes Yards and brought down the Illinois and Mississippi Rivers.

Source: [Ref.13]

4. Conclusion

Military use of the inland waterways goes back to the founding of this nation. The invention of the steamboat with its upstream capability enlarged the military potential of the rivers. The Civil War demonstrated that the military could move large forces of men and supplies efficiently on the inland waterways. World War I showed the capability of the inland waterways to supplement the railroads during a nationwide mobilization effort.

The inland waterways proved to be a robust transportation system during World War II. The vast network of waterways made two major contributions to the victory. The waterway system was essential to the movement of petroleum products to the East Coast and the inland waterways provided passage for military craft built at inland shipyards. In addition, the waterways served in a supplemental role for other commodity movements.

One of the reasons the railroads and the inland waterways were the primary movers of material during the war was the limited highway system. By 1921, only 387,000 miles of America's roads were paved and less than four percent of freight moved on the roads [Ref.7:p.112]. After World War II, the federal government set into place a program for an interstate highway system. Improved military mobilization was one of the primary goals of this program. In the postwar years, the highway system improved and usage increased, yet interest in waterborne movement by the military declined. This study discusses the rediscovery of the inland waterways by the military.

III. THE PRESENT INLAND WATERWAYS INDUSTRY

A. INTRODUCTION

"The physical transportation plant of the United States is composed of a variety of types of rights of way, terminal facilities, vehicles which provide locomotive power and which contain space for freight or passengers, communications equipment to facilitate centralized operational or managerial supervision or control over far-flung activities, and numerous forms of specialized accessorial equipment designed to make the transportation process more efficient or to cater to the needs of particular types of freight or passenger traffic." [Ref.1:p.49]

Railroads, highways, pipelines, airlines, and waterways are the primary agencies responsible for moving domestic freight in this complex transportation system. This chapter will present the important physical features and characteristics associated with one of these key transport modes, the inland waterways.

The first section of the chapter displays the commodity groups that move on the inland waterways, including Department of Defense (DOD) movements. The next section describes the five principal inland waterway systems. The third section of the chapter reviews the physical equipment and facilities on the inland waterways. The fourth section of the chapter discusses the influence of the United States Army Corps of Engineers (USACE) on the inland waterway system. The first four sections of the chapter provide a broad-brush profile of the inland waterway industry.

The final section of the chapter attempts to determine the appropriateness of the industry to support national mobilization efforts.

B. COMMERCE ON THE INLAND WATERWAYS

Commodity groups that show the most advantage for waterborne movements are large bulk cargos that have little urgency about their movement. [Ref.15:p.230] As shown in Table 3, petroleum and petroleum products accounted for 35.5 percent of total tonnage moved on the inland waterways in 1988.

TABLE 3

PRINCIPAL COMMODITIES CARRIED BY WATER 1988

Commodity	Percent
Petroleum and Products	35.5
Coal and Lignite	23.8
Sand, Gravel, and Stone	9.6
Chemicals	8.9
Grain, Seed	8.9
Others	8.0
Iron and Steel	1.5
Logs and Lumber	1.4
Clay, Glass, and Concrete	1.2
Non-Metallic Minerals	1.2

Source: [Ref.16]

Dry bulk commodities such as coal, sand, gravel and stone, and grain accounted for another 42.3 percent of total tonnage. As indicated by Tables 4,5,and 6, the commodity mix on the inland waterways has remained fairly constant over the past three decades. As shown in Table 7, DOD primarily uses the inland waterways to ship petroleum products.

TABLE 4

PRINCIPAL COMMODITIES CARRIED BY WATER 1965

Commodity	Percent
Petroleum and Products	37.2
Coal and Coke	16.5
Iron and Steel	11.8
Sand, Gravel, Stone	8.2
Grains	5.0
Logs and Lumber	3.1
Chemicals	3.5
Seashells	1.9
Others	12.8

Source: [Ref.17:p.19]

TABLE 5

PRINCIPAL COMMODITIES CARRIED BY WATER 1974

Commodity	Percent
Petroleum and Products	42.1
Coal and Coke	13.1
Iron and Steel	9.8
Sand, Gravel, and Stone	7.3
Grains	5.6
Logs and Lumber	3.0
Chemicals	5.5
Seashells	1.0
Others	12.6

Source: [Ref.18:p.11]

TABLE 6

PRINCIPAL COMMODITIES CARRIED BY WATER 1984

Commodity	Percent
Petroleum and Products	39.9
Coal and Coke	15.9
Iron and Steel	6.3
Sand, Gravel, and Stone	1.7
Grains	8.9
Logs and Lumber	2.5
Chemicals	7.0
Seashells	0.3
Others	14.5

Source: [Ref.19:p.11]

TABLE 7

PRINCIPAL DOD COMMODITIES CARRIED BY WATER 1989

Commodity	Percent
Petroleum and Products	94.9
Miscellaneous	5.1

Source: [Ref.4:p.7]

C. PHYSICAL DISTRIBUTION OF THE INLAND WATERWAYS SYSTEM

A series of slack-water pools, free-flowing rivers, and coastal canals make up the nation's inland waterways system [Ref.20:p.145]. The principal physical components of the Inland Waterways system are illustrated in Figure 1. This waterway system provides 25,777 miles of commercially navigable rivers and canals exclusive of the Great Lakes. More than 15,350 miles of this inland waterway system have a channel depth of at least nine feet. For most commodities, water carriers consider seven and one-half feet the minimum operating depth for economical operations. [Ref.22:p.312] In addition to carrying the nation's freight, the inland waterways serve as a water resource provider. Irrigation, hydropower, flood control, municipal and industrial supply, fish and wildlife habitat, and recreation interests all compete for scarce water allocations. [Ref.22:p.311]

The principal inland waterway systems are:

1. <u>The New York State Barge Canal</u>: This canal traverses the state and connects New York Harbor with the Great Lakes system and the St. Lawrence Seaway [Ref.23:p.270]. Unique among the inland waterways, the state maintains and operates this canal. All other inland waterways are federal projects. [Ref.6:p.13] The canal system has widths ranging from 75 to 200 feet and a minimum depth of twelve feet. There are 34 locks in the 522 mile canal. Unfortunately, small lock capacity has limited navigation to local traffic. [Ref.8:p.295]

2. <u>The Atlantic Intracoastal Waterways System</u>: This series of natural coastal bays and connecting channels reaches from Boston, Massachusetts to southern Florida. A series of tributary rivers and manmade canals on the eastern seaboard feed this protected inland waterway. [Ref.8:p.293]

3. <u>The Mississippi River System</u>: The nation's largest connected waterway system has more than 8,954 miles of improved waterways and flows into 18 states. [Ref.8:p.288] This system provides direct connection for shallow draft vessels to both the Great Lakes and the Gulf of Mexico. [Ref.23:p.270]

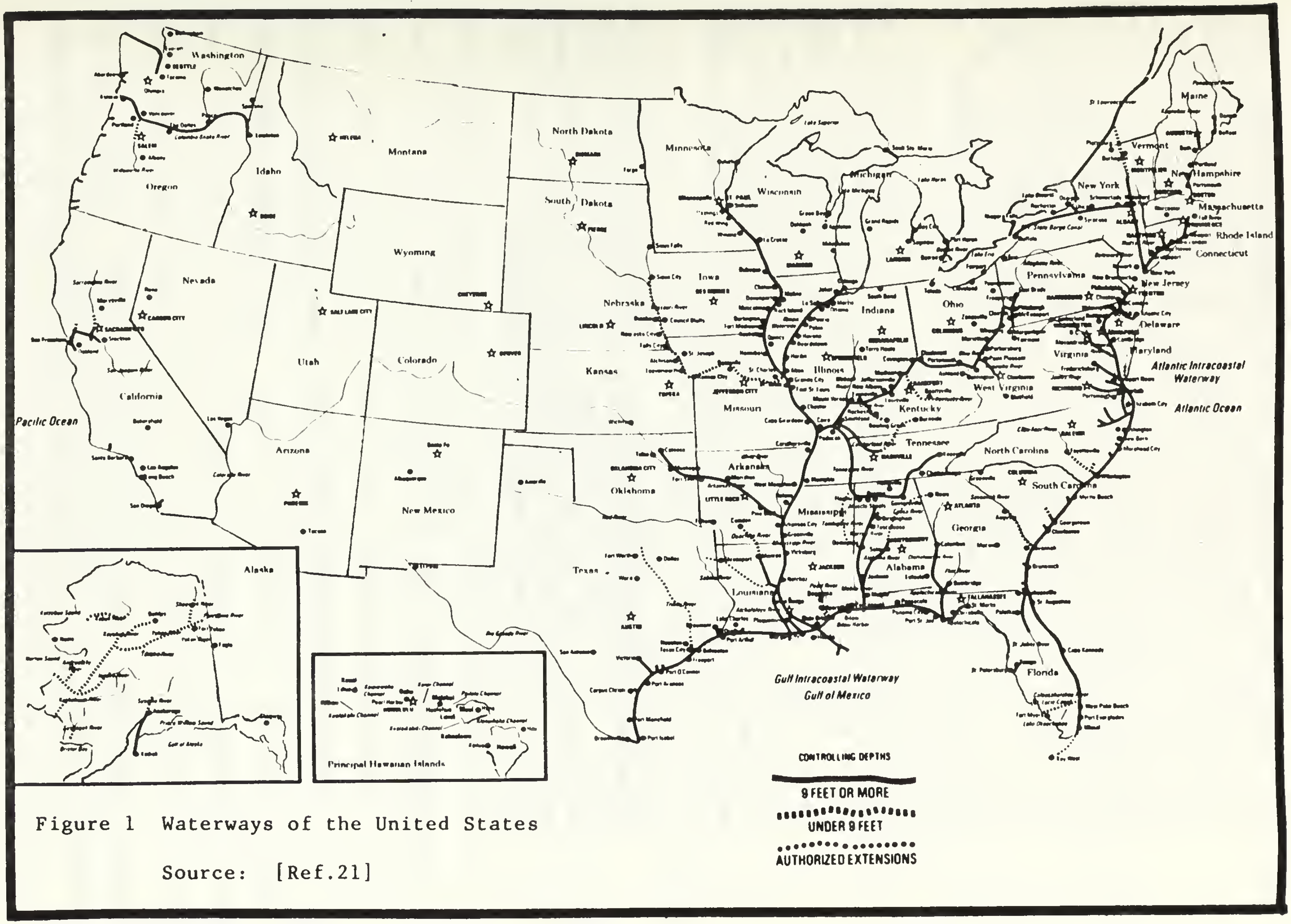


Figure 1 Waterways of the United States

Source: [Ref.21]

The trunk of this system is the 2,348 mile Mississippi River. Due to sudden changes of course, its length varies by 40-50 miles per year. [Ref.24:p.830] The navigable section of the Mississippi River begins at Minneapolis, Minnesota and flows in a southerly direction to the Gulf of Mexico at New Orleans. The inland waterways industry divides the river into two sections, the upper Mississippi and the lower Mississippi. The upper reach of the Mississippi (Minneapolis to the mouth of the Missouri River, just above St. Louis) includes 663 miles of navigable waterway and 27 dams and locks. [Ref.8:p.288] The lower reach of the Mississippi (St. Louis to New Orleans) provides more than 1,000 miles of open river. The major tributaries to the Mississippi River system include the Ohio River, Missouri River, Illinois Waterway, and Arkansas River. [Ref.25:p.8]

4. The Gulf Intracoastal Waterways System: This system provides 1,108 miles of protected waterways along the Gulf coast and extends from the St. Marks River at Jacksonville, Florida to Brownsville, Texas. About one-half of the waterway uses existing lakes, bays, and other natural water bodies. [Ref.8:p.291] A large system of feeder waterways connect with the Gulf Intracoastal Waterways, including the Tennessee-Tombigbee system and the Mississippi River. Barge operators use New Orleans to divide the system into an eastern section and a western section. [Ref.25:p.9]

5. The Pacific Coast Waterways System: The Columbia and Snake River system provides 340 miles of navigable waters from Lewiston, Idaho, through the state of Washington, to the Pacific Ocean. [Ref.23:p.270] The Willamette River, with 132 miles of improved channels and the 245 mile Sacramento River system are the other major Pacific navigation channels. [Ref.8:p.289]

D. EQUIPMENT AND FACILITIES ON THE INLAND WATERWAYS

1. Industry Structure

About 800 towing companies operate more than 36,000 pieces of equipment over the inland waterways system. These companies employ more than 176,000 people. Personnel are employed both aboard the inland fleet and in shore-based work directly connected with towboat and barge companies. [Ref.16] Today the inland waterways industry has an estimated 5,188 towboats and tugs with a total horsepower of 8,550,068.

These companies operate a fleet of 31,000 dry and liquid cargo barges with a combined carrying capacity of 45 million net tons. [Ref.16]

2. Towboats and Tugboats

A wide variety of towboats and tugboats make up the vessels that work on the inland waterways today. Modern towboats and tugboats have the typical dimensions and horsepower shown in Figure 2.

Tugboats: Operators use tugboats for pull-towing operations. These "on-the-hip operations" often take place in an industrial harbor or in open water along the Atlantic and Gulf Intracoastal Waterways. [Ref.23:p.272]

Towboats: The industry uses towboats for push-towing operations where surrounding land masses protect the water routes. They also use towboats where the waters are either calm in their natural state or where a system of locks and dams creates slack water. [Ref.6:pp.10-11]

Compared to push-towing, pull-towing operations severely limits the number of barges a power unit can move. For the more efficient push-towing method, towboat crews lash barges ridgedly together, side by side and back to front, to form a single tow. Then, they securely lash the barge tow to the boat's flat towing knees at the forward end of the boat. [Ref.6:p.11] In this manner, one 10,500 horsepower towboat can push a 40 barge unit. [Ref.26]

TOWBOATS	Length Feet	Breadth Feet	Draft Feet	Horsepower
	117	30	7.6	1000 to 2000
	142	34	8	2000 to 4000
	160	40	8.6	4000 to 6000

TUGBOATS	Length Feet	Breadth Feet	Draft Feet	Horsepower
	65 to 80	21 to 23	8	350 to 650
	90	24	10 to 11	800 to 1200
	95 to 105	25 to 30	12 to 14	1200 to 3500
	125 to 150	30 to 34	14 to 15	2000 to 4500

Figure 2 Inland River Power Units

Source: [Ref.15]

The industry divides towboats into three groups based on their rated horsepower:

1. Towboat companies use low horsepower fleetboats to bundle and sort barges alongside terminals. These 700 to 1500 horsepower workboats also move barges to and from fleeting areas, and to break off or add barges to linehaul tows moving in midstream.

2. Medium horsepower, 1,500 - 5,000 horsepower, linehaul towboats make up the bulk of the industry's available horsepower. They move most of the multiple barge tows on all waterways.

3. High horsepower, 5,000 - 10,500 horsepower, linehaul towboats push the larger tows on the swift, but broad expanses of the lower Mississippi River. [Ref.5:p.5]

Highly efficient and dependable diesel engines power most modern towboats. By using reversing-reduction gears, the shafts transfer the developed energy efficiently to the vessel's propellers. A common powerplant consists of twin diesels mated to a pair of four blade propellers with a gear ratio of 4.1:1 to 4.9:1. [Ref.27:p.7]

Modern pilothouses rise as high as 40 feet above the water to give boat pilots better visibility over the barge tows. Sophisticated electronic equipment, such as radar and depth finders, allow round-the-clock operations in all kinds of weather and channel conditions. [Ref.8:p.289] Standard equipment on towboats include electronic steering and engine controls, automatic electric bilge pumps, searchlights and airhorns, and a variety of radio communications.

3. Barges

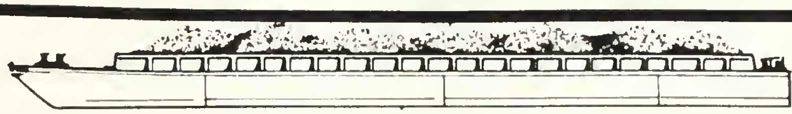
One of the strengths of the inland waterway industry is the ability to carry heavy bulk commodities in specifically designed vessels. As the quantity of packaged goods diminished from inland waterways commerce, water carriers developed barges to carry a variety of bulk commodities. These commodities included: coal, ores, grain, iron and steel products, petroleum and petroleum products, chemicals, and building materials. [Ref.23:p.271]

Figure 3 illustrates the four basic types of barges. The most common forms are the hopper types of barges.

Open hopper barges transport dry cargo commodities which do not require protection from the weather. Weather-impervious commodities commonly moved by these barges include coal, steel and ore, gravel, and lumber. [Ref.23:p.272] Covered dry cargo hopper barges, with sliding weathertight hatch covers, transport commodities which require protection from adverse weather elements. Such goods include grains and agricultural products, paper products, and salt. [Ref.23:p.272]

Deck barges carry heavy and outsized equipment such as construction equipment, oil rig equipment, and military vehicles and equipment. [Ref.23:p.272]

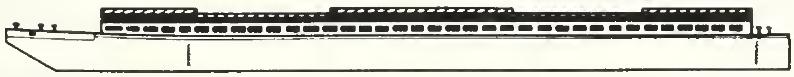
Liquid cargo tank barges move the biggest commodity loads on the inland waterways, which are petroleum and petroleum products. In addition to petroleum products, tank barges also move chemicals, liquid fertilizers, and fruit juice. [Ref.23:p.272]



Open Hopper Barge

195 feet long
1530 ton capacity

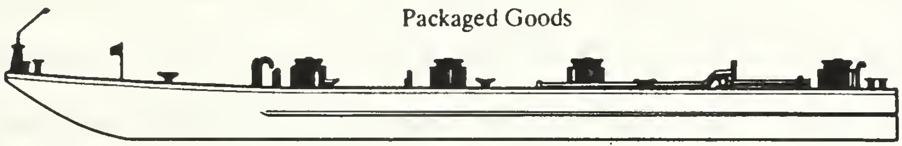
Carries: Coal
Steel and Ore
Sand and Gravel
Lumber



Covered Dry Cargo Barge

195 feet long
1500 ton capacity

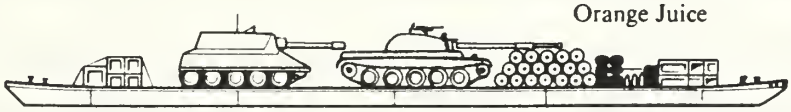
Carries: Grain, soybeans
Coffee, Salt, Sugar
Paper Products
Packaged Goods



Liquid Cargo (Tank) Barge

297 feet long
1,000,000 gallon capacity

Carries: Petroleum & Petroleum products
Liquid Fertilizers
Industrial Chemicals
Orange Juice



Deck Barge

200 Feet long
2,000 ton capacity

Carries: Spacecraft
Construction Equipment
Prefabricated Buildings
Military Equipment
Oil Rigs

Figure 3 Inland River Barge Types

Source: [Ref.28]

4. Inland Ports and Terminals

To support the growth of the inland waterways, river terminals have evolved into complex intermodal transportation and distribution centers. Today, specialized or general cargo terminals make up the modern inland port. These terminals provide for the handling of freight to and from barges. Each terminal usually serves one type of commodity and will have docks, storage areas, and cargo transfer facilities. [Ref.29:p.491]

Typical dry bulk terminals can handle the transfer of any type of dry material. Common dry commodities shipped outbound to barge or inbound to truck or rail include such products as grains, coal, and ore. [Ref.30] Covered and dry storage facilities are also available at dry bulk terminals.

Modern public liquid terminals consist of a tank farm and a dock-barge. The transfer rate for discharging or loading bulk liquid can reach 3,000 barrels per hour. The liquid products transferred from railcars, trucks, and barges include: caustic soda, liquid fertilizer, petroleum products, and soybean oil. [Ref.30]

Public general cargo terminals have heavy-lift capability cranes and conveyors with high ton per hour capacity. Many general cargo terminals have Roll-on/Roll-off (RO/RO) capability.[2]

In addition to waterway facilities, rail and truck transportation modes provide linkage to off-port transportation, distribution, manufacturing, and commercial facilities [Ref.30]. These transportation modes require access to the port and a significant amount of space within

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[2] RO/RO capability allows loading and unloading without the use of dockside cranes.

the defined port area. Each mode requires space to park full and empty units, service areas, and space to load and unload the units. [Ref.30] The efficiency and capacity of an inland port's harbor and fleeting service also determines cargo capacity and transfer rate. Tows stopping at the port will either travel directly to a terminal for service or move to a fleeting area to await switching and shuttle service. [Ref.29:p.490]

5. Locks and Dams

Winter freezes, spring thaws, and summer droughts produce wide variations in the depths of a natural river. To permit year-round navigation on such rivers, the United States Army Corps of Engineers (USACE) uses a series of dams to maintain a constant depth. The dams play an important part in providing enough deep water for navigation activities and acting as a source of flood control. [Ref.15:p.220] To move river traffic from one level to another level created by the dams, the USACE constructs, operates, and maintains navigation locks. [Ref.15:p.219] Navigation locks on the inland waterways are chambers that fill with water. They hydraulically raise and lower their elevation to accommodate passage between two waterway levels of different depth. Typical lock sizes are 110 by 600 feet and 110 by 1,200 feet. [Ref.15:pp.216-217]

On the inland waterways, locks are the primary cause of bottlenecks and delays. Three factors contribute to the time limiting influence of locks: lockage time, multiple lockages, and lockage congestion.

Towboat operators allow about thirty minutes as the average amount of time for a barge tow to pass through a lock. Four parts make-up this lockage time. [Ref.31:pp.430-431]

1. The approach time - time necessary for a tow to move from an approach point to the lock gate sill.

2. Entry time - time measured from when the tow's bow crosses the sill until the crew secures the tow in the chamber.

3. Chambering time - time measured from when the crew secures the tow in the chamber, exit gates are recessed, and the horn has sounded.

4. Exit time - time measured from when the horn sounds until the tow reaches the approach point. [Ref.31:pp.430-431]

As stated earlier, the USACE estimates the average lockage time at thirty minutes. However, when multiple lockage occurs, one to one and a half hours per tow is not unusual. [Ref.15:p.220]

Multiple lockage occurs when tow size, the number of its barges, exceeds the lock chamber size. When this occurs, the towboat's crew must separate the tow's fleet of barges, lock them through in several cuts, and reassemble the tow. Break-up and reassembly of the tow causes the multiple lockage to take even more time than locking different tows, each less than chamber size. For a lock chamber with a capacity of 17 barges and one towboat, a tow with 18 barges takes longer than two tows with 17 barges each. [Ref.31:p.758]

Congestion is a function of lock capacity and traffic characteristics. The previous paragraph discussed the time constraints imposed when tows reach lock capacity. Traffic characteristics that influence congestion include:

1. Size of the tow - the number of barges

2. Draft of the unit - the draft affects speed and maneuverability

3. Direction of travel - imbalanced traffic

4. Itinerary followed - route through bottleneck locks [Ref.6:p.92]

Regardless of the cause of congestion, the user still incurs costs. "When a tow and its barges wait in a queue to transit a lock, excess payments for crews and fuel are made, returns to capital are foregone, and payments for cargo are postponed." [Ref.32:p.759]

E. THE UNITED STATES ARMY CORPS OF ENGINEERS (USACE)

More than a 150 years ago, Congress authorized the United States Army Corps of Engineers to develop the inland waterways for commercial navigation. The USACE has been responsible for planning, construction, maintenance, improving, and operating inland waterways, including harbors. Their responsibilities include:

1. Developing engineering feasibility and cost studies

2. Performing economic analysis

3. Providing to Congress overall justification data for river and harbor improvements

4. Maintaining channels at their authorized depth and width

5. Maintenance of harbors, including jetties and breakwaters

6. Providing navigation lighting and marking

7. Modernization of system locks

8. Removal of obstructions that could hinder navigation on the inland waterways [Ref.6:pp.16-17]

In addition to navigation, Congress charged the USACE to consider the nation's total water needs. These include flood control, agriculture, industry, recreation, the supply and quality of water, and the generation of hydroelectric power. [Ref.33:p.40]

"In the past decade, the number of uses for existing waterways has increased substantially." [Ref.33:p.40] Waterway users now view the inland waterway system as another source of income. In addition to navigation, the commercial fishing, hydropower, irrigation, and recreation interests are also competing for water [Ref.33:p.40]. These increased demands on the waterways coupled with concurrent droughts and floods have increased public awareness of USACE management of the inland waterway system.

Recently, user groups have banded together to pressure Congress to force the USACE to change its water allocation priorities. Three states have filed a lawsuit to prevent water releases from state reservoirs. These releases are necessary to keep miles of rivers navigable for barge traffic. [Ref.33:p.42] The USACE maintains that navigation is its number one priority. The USACE further argues that it does not have the authority to withdraw support from navigation and that it only releases enough water to support minimal barge traffic. [Ref.33:p.42]

F. MOBILIZATION AND THE INLAND WATERWAYS

The inland waterways provide about one-sixth of the nation's freight transportation [Ref.34:p.142]. If mobilization occurs, many elements of the waterways structure could expand their capacity.

1. Ports and Terminals

The transfer times of towboat and barge cargoes at inland waterway ports depend upon a variety of factors. These factors include the facilities, equipment, and labor skills provided by the terminals that make up the port. The competence and capacity of the fleeting service used by the port also influences cargo capacity. In the short term, these characteristics do not lend themselves to emergency expansion. However, analytical models of inland port operations show that terminals could realize some short term improvements. According to one model, improving material handling equipment and extending operating periods could significantly increase terminal capacity and reduce total load and unload time. [Ref.29:pp.490-497]

2. Rivers and Channels

Open river navigation could rapidly expand to meet increased mobilization demands. The primary bottleneck occurs where locks and dams make slack water navigation possible. The 167 locks that make up the inland system have a median age of 35 years. Many of these locks are requiring increased amounts of maintenance to insure their continuous operation. Additionally, lengthy and expensive delays at some of the older locks have become common as traffic reaches the lock's capacity [Ref.4:p.11]. The modernization of a waterway is a lengthy and expensive

project, as shown by the modernization of the Black Warrior-Tombigbee navigation system. The dedication of the $118 million William Bacon Oliver lock on August 17,1991 completed a modernization program that began in 1954. The new 600 by 110 foot structure replaced a 460 by 95 foot lock opened in 1939. In total, the federal government has $237 million invested on the Black Warrior-Tombigbee Waterway. [Ref.35:p.5]

3. Towboats and Barges

Studies have found that the normal use of tugs, towboats, and barges is about 65 percent of a hypothetical maximum. Under emergency conditions, the industry believes that 80 percent usage is possible. This reserve is a result of the extra capacity water carriers require during seasonal surges and due to unbalanced directional flow of traffic. Additionally, most towboats do not operate at full load capacity and the industry could add many barges to tows. [Ref.20:p.34]

In recent years, waterways have seen significant increases in water consumption. Multiple year drought conditions have made these waterflow constraints worse. Drought conditions limit input to the stream flow while increasing overall water consumption.

Barge operators have responded to these water flow limitations by limiting the loads carried by individual barges. This "light loading" insures that the draft of the tow is not greater than the expected minimum depth of the waterway. [Ref.22:p.311] Depending on the change in priority of water allocation and rainfall, barges could operate with heavier loads [Ref.20:p.273]. This option provides for a significant increase in capacity at a marginal increase in cost. The costs of moving a barge

loaded to a nine foot draft are almost the same for moving a barge loaded to eleven feet. [Ref.22:p.317] "As a rule of thumb, six inches in draft is equal to 100 tons of cargo for a 35 foot by 195 foot barge." [Ref.22:p.317]

If mobilization requires maximum use of the active floating plant, the industry could introduce additional unused inland water equipment. However, the depressed coal and grain markets have limited new construction in the workboat industry. [Ref.33:p.45] The barge fleet is showing limited growth for similar reasons. There are excesses left from thousands of barges that shipyards built as the result of investors seeking tax shelters. [Ref.33:p.44]

The towboat and barge industry has seen the cost of capital investment significantly increase. A barge costing $98,000 in 1976 will cost more than $250,000 today, depending on market conditions. [Ref.36:p.75] A new towboat can cost anywhere from $2 to $7 million, again depending on market conditions [Ref.33:p.45]. Table 8 profiles new towboat construction in the United States. New construction is primarily replacing the few U.S. towboats that operators in South America buy each year. The industry also uses new construction to replace the handful of towboats lost to fires, accidents, and retirements. [Ref.33:p.46]

Towboat owners believe that the current market environment dictates overhauling old equipment instead of buying new equipment. Companies are refurbishing and updating. They are replacing old engines with more powerful and fuel efficient modern engines, adding to their bottom line by providing more

TABLE 8

TOWBOAT NEW CONSTRUCTION SURVEYS

Year	Quantity Built
1980-1983	126
1984	9
1985	6
1986	1
1987	2
1988	3
1989	42
1990	40*

Note: The results of the surveys are limited by the number of shipyards responding to them.

* Estimate only

Source: [Ref.33:p.45]

ton miles with less fuel burned [Ref.33:p.46]. This suggests that in a full and protracted mobilization the existing power plants would rapidly reach their maximum cargo capacity. To expand cargo capacity, in the short term, the industry would have to use obsolete units.

Another method of judging maximum operational abilities is to compare the inland waterways against the railroad. The railroad is the benchmark against which industry frequently measures other modes of transportation. Railroad costs of equipment, fuel consumption, labor productivity, and repair costs are often compared to other modes when evaluating the following three measurements: [Ref.23:p.275]

1. The ratio of equipment weight to carrying capacity; this measures the most beneficial use of the nation's raw materials. A 70 ton capacity freight car weighs 29 tons empty. [Ref.15:p.189] A barge weighing 170 tons has a carrying capacity of 900 tons. Barge transportation has a more favorable 5.3:1 ratio of equipment weight to carrying capacity than the railroad's ratio of 2.4:1. [Ref.23:p.176]

2. The ratio of equipment cost and fuel consumed to carrying capacity. In terms of cost of equipment, a ton of barge space is more economical than a ton of railroad space. A defense dollar spent for barge transportation will buy almost three times the cargo capacity that a dollar invested in railroad equipment would purchase. [Ref.23:p.276]

   During a mobilization, the amount of fuel that the nation's transportation system requires would be a major concern [Ref.23:p.276]. Barge transportation is the most fuel efficient method of moving the bulk commodities that the nation would need during a crisis. [Ref.16] Table 9 shows the fuel efficiency of the four major modes used to move raw materials.

3. Comparison of labor productivity and maintenance costs. [Ref.23:p.275]

   "The effectiveness of any transportation mobilization effort, to a great extent, depends on the most effective utilization of the nation's manpower resources." [Ref.237:p.276] Barge transportation is not labor intensive. Plus, industry can almost double the size of a tow without any large increase in the manpower of the barge crew. [Ref.23:p.277]

   "In 1986, 5.45 million ton miles of freight were transported for each water carrier employee." [Ref.34:p.152] During mobilization, barge transportation would place less than one-half the drain on the nation's manpower resources to generate the same amount of transportation compared to railroad manpower requirements [Ref.23:p.277].

TABLE 9

FUEL EFFICIENCY

Mode	Miles one ton of commodity can move per gallon
Rail	202.0
Highway	59.2
Waterway	514.0
Pipeline	492.0

Source: [Ref.16]

G. SUMMARY

The inland waterway industry moves more than 13 percent of the nation's freight for two percent of the nation's total transportation cost. [Ref.16] For the movement of bulk commodities during mobilization, barge transport would require less manpower and cost less in operating and total costs than any other mode of transportation.

Today, the United States has a very robust inland waterway transportation system. [Ref.1:p.35] The equipment and facilities of the inland waterways are critical components of the nation's capacity to operate. Inland waterway transportation contributes to the nation

socially, economically, culturally, and for the purposes of national defense. [Ref.15:p.3]

IV. CURRENT MILITARY USE OF THE INLAND WATERWAYS

A. INTRODUCTION

During World War II, the inland waterway system moved more than four million tons of military material and equipment. War material and newly constructed naval craft from inland factories and shipyards moved on the inland waterways system to ocean seaports. [Ref.37:p.23] However, since the end of that war, the military has not widely used the inland waterways. Contracting for rail or truck transportation has been the standard procedure for moving heavy military equipment. Decision makers have presumed rail and truck movement to be faster, less difficult, more customer responsive, and more cost effective.

This chapter will examine these presumptions by:

1. Providing a brief chronology of current military shipments on the inland waterways
2. Providing a review and analysis of significant military movements of the inland waterways
3. Comparing the various modes used for military movements
4. Providing conclusions

B. CHRONOLOGY OF MILITARY UNIT MOVEMENTS ON THE INLAND WATERWAYS

This section provides a chronological listing of all military unit movements on the inland waterways during the last five years. The listing shows the date, organization, type and quantity of equipment, and destination of the movement.

1. January 1986 - The 211th Engineer Dredge Detachment, Texas Army National Guard (TXARNG). moved a M88 Vehicle Tank Retriever for the United States Army Reserve (USAR). The move from Pleasure Island, Texas to Lake Charles, Louisiana, was less than 35 miles. [Ref.38:p.2]

2. April 1986 - The 120th Engineer Battalion, Oklahoma Army National Guard (OKARNG), moved six tracked vehicles from Camp Gruber, Oklahoma to Fort Chaffee, Arkansas [Ref.38:pp.1-2].

3. May 1986 - The 386th Engineer Battalion, TXARNG, moved 27 pieces of heavy equipment from Houston, Texas to Fort Chaffee, Arkansas [Ref.38:pp.2-3].

4. June 1987 - The 120th Engineer Battalion, OKARNG, moved 34 pieces of heavy equipment from Camp Gruber, Oklahoma to Fort Chaffee, Arkansas [Ref.39:p.2].

5. June 1987 - The First Battalion, 142nd Field Artillery, Arkansas Army National Guard (AARNG), moved 164 pieces of equipment from Fort Chaffee, Arkansas to Camp Grayling, Michigan [Ref.39:p.4].

6. May 1988 - The 45th Infantry Brigade, OKARNG, moved 17 pieces of equipment from Camp Gruber, Oklahoma to Fort Chaffee, Arkansas [Ref.40:p.1].

7. June 1988 - The Second Battalion, 142nd Field Artillery, AARNG, moved 241 pieces of equipment from Fort Chaffee, Arkansas to Camp Atterbury, Indiana [Ref.40:p.1].

8. April 1989 - The First Battalion, 189th Field Artillery, OKARNG, moved 134 pieces of equipment from Camp Gruber, Oklahoma to Fort McCoy, Wisconsin [Ref.41].

9. May 1989 - The United States Army moved 12 pieces of equipment from Fort Chaffee, Arkansas to Camp Gruber, Oklahoma [Ref.42].

10. September 1989 - The Second Brigade, 101st Airborne Division, moved 630 pieces of equipment from Fort Campbell, Kentucky to Fort Chaffee, Arkansas and Camp Gruber, Oklahoma [Ref.37].

11. January 1990 - The 20th Engineer Battalion (Combat), 101st Airborne Division, moved 112 pieces of equipment from Fort Campbell, Kentucky to Belize in Central America [Ref.43:p.4].

12. September 1991 - The 372nd Transportation Company, 101st Airborne Division, moved 529 pieces of equipment from Fort Campbell, Kentucky to Fort Chaffee, Arkansas [Ref.44:p.7].

Recent successful use of the inland waterways by Active, Reserve, and National Guard units has encouraged the Department of Defense to reevaluate the military value of the nations's inland waterways. These unit movements demonstrated that waterway transport, as rail and truck alternatives, can save transportation dollars.

C. KEY MOBILIZATION EXERCISES USING THE INLAND WATERWAYS

This section discusses four organizational moves which may influence future mobilization plans. The section examines these key moves to determine if there is evidence that movement by the inland waterways can realize substantial savings in transportation cost and enhance training.

1. Oklahoma Army National Guard Movement 1986

In October 1985, the OKARNG asked the Tulsa District, Army Corps of Engineers (USACE), to help them conduct a test move over the McClellan-Kerr Arkansas River waterway. The test plan called for moving heavy equipment from Camp Gruber, near Muskogee, Oklahoma to Fort Chaffee, Arkansas. In November, OKARNG officers conducted a reconnaissance trip over the waterway and completed drafting unit movement requirements. In

January and February of 1986, the OKARNG made formal support requests for use of the waterway during April 1986. [Ref.45:p.1]

On April 8, 1986, the USACE towboat Sallisaw, with a two barge tow, arrived at Boudinot Safety Harbor, River Mile 382, near Muskogee, Oklahoma. The Guard secured the two Army barges against the bank. The barges were standard-sized river barges. The deck barge measured 35 feet by 120 feet and the crane barge was 35 feet by 150 feet. The OKARNG then built an earthen ramp from the bank to the barges for drive-on loading. Loading of the OKARNG equipment was done on 9 April, 1986 in less than thirty minutes. The tow left the loading site at 1230 hours, passed through the Webbers Falls Lock and Dam at River Mile 366.5 and secured for the night at the United States Coast Guard/USACE Terminal at Kerr Reservoir at 1800 hours. The tow left the terminal at 0600, 10 April, and arrived at the Fort Chaffee loading site near Lock and Dam (L&D) 13 at 1415 hours. Guard personnel unloaded the equipment in about one hour. [Ref.45:p.2] During the period of 17-19 April, the same tow returned the OKARNG equipment to Camp Gruber after the completion of the training exercise.

a. *OKARNG Equipment Load Manifest*

The move totaled six pieces of equipment including:

1. three MI06AI mortar carriers
2. two CEV M728 combat engineer vehicles
3. one AVLB M48A2 armored vehicle launched bridge. [Ref.45:p.2]

b. *Unit Movement Analysis*

Historically, the OKARNG has used commercial trucks to move equipment between Camp Gruber, Oklahoma and Fort Chaffee, Arkansas. Therefore, the only two modes of transportation reviewed for the test comparison were commercial trucking and commercial barges.

(1) Commercial Truck. The distance between Camp Gruber and Fort Chaffee is approximately 70 highway miles. Past highway unit moves have taken about two hours. The total truck bid to move the OKARNG equipment round trip, excluding the AVLB, was $10,190.00. Truck movement requires dismantling the AVLB. [Ref.46]

(2) Commercial Barge. The distance, by waterway, between the two facilities is about 93 miles. The estimated cost of using a commercial version of the USACE towboat and barges for the round trip waterway movement was $3,700. The tow covered the 93 miles at an average speed of 5.4 miles per hour including lock time. [Ref.46]

Table 10 provides a round trip comparison of the two modes.

TABLE 10

OKARNG MOVEMENT (1986) COST COMPARISON

Commercial Truck (bid estimate)	$10,190
Commercial Barge (estimate)	3,700
Cost Savings	$ 6,490

Source: [Ref.46]

The OKARNG and USACE promoted the move as the first major unit movement on the inland waterways since World War II. This small test movement showed that barge transportation can be fast, easy, and cost effective. However, the test move also showed that major benefits occur when:

1. there is a requirement to move heavy and outsized equipment between installations that are near and accessible to the inland waterways
2. there is enough equipment to make maximum use of available barge deck space.

For this movement the tow was well under capacity. The test tow carried only three mortar carriers. One commercial deck barge, similar to the one used in the move can accommodate up to 18 M106A1 Mortar Carriers. The incremental cost of additional fuel to move a fully loaded barge is relatively small [Ref.34:p.154]. The total cost to move 18 mortar carriers would have been about the same as moving the three carriers.

Waterborne movement allowed the Guard to load the outsized AVLB onto the barge without any disassembly, saving labor and equipment cost. [Ref.46] As an added benefit, the Guard was able to use the AVLB to unload the barged equipment at Fort Chaffee, Arkansas. Using the AVLB saved additional time, labor, and equipment cost [Ref.45:p.2]. Guard officials reported no problems during the downbound or upbound movements. [Ref.45:p.3]

2. Texas Army National Guard Movement 1986

On May 7, 1986, the 386th Engineer Battalion, TXARNG loaded 27 pieces of combat engineer equipment on two army deck barges. The loading site was the Roll-On/Roll-Off (RO/RO) dock, Port of Houston, Texas. The Belmont and tow left the same day and traveled the Gulf Intracoastal Waterway (GIWW) to Morgan City, Louisiana. From Morgan City, the tow traveled on the Port Allen Cut-off to enter the lower Mississippi at Baton Rouge, Louisiana. The cargo then moved upstream to River Mile 599 and entered the McClellan-Kerr Arkansas River system. On 17 May, the tow arrived at Fort Chaffee and began off-loading at the unimproved site. The TXARNG travelled on five different portions of the inland waterway system, transited 17 locks and covered 1,150 miles. [Ref.38:pp.2-3]

a. *TXARNG Equipment Load Manifest*

The move totaled 27 pieces of equipment including:

1. three 10-ton Trailers
2. three D-7 Caterpillars
3. one 5-ton Tractor
4. three Scoop Loaders
5. three M880's
6. two 5-ton Dumps
7. one Staff Car
8. two 2-1/2-ton Trucks
9. one Blazer
10. three Miscellaneous Trailers

11. five Miscellaneous Vehicles [Ref.47]

b. Unit Movement Analysis

Estimated cost for water movement from Houston, Texas to Fort Chaffee Arkansas was $15,628. Estimated costs for vehicular movement including combination commercial truck movement and military convoy were $57,944. [Ref.38:pp.C-19-20]

Table 11 is a simple cost comparison between the OKARNG and TXARNG movements. The cost comparisons show that for waterborne military unit movements to provide a major advantage, large volume per barge is necessary. In other words, as the deck space per barge is filled up, the savings, using water, increases. In the test movements, length of haul did not have a major influence on the cost. [Ref.38:p.5]

TABLE 11

OKARNG AND TXARNG MOVEMENTS (1986) COST COMPARISON

OKARNG	93 Miles	6 Track Vehicles	2 Deck Barges
TXARNG	1100 Miles	27 Heavy Vehicles	2 Deck Barges
	AKARNG Movement April 1986		
Commercial Truck			$10,190
Waterway			3,700
Savings			$ 6,490 (64%)
	TXARNG Movement May-June 1986		
Commercial Truck (6 pieces)			$47,000
Military Convoy (21 pieces)			10,944
Total			$57,944
Waterway (27 pieces)			$15,628
Savings			$42,366 (73%)

Source: [Ref.39:p.5]

3. Arkansas Army National Guard Movement 1987

On June 7, 1987, the First Battalion, 142nd Field Artillery, AARNG completed the on-load of seven commercial ocean-going barges. The waterborne military convoy departed the Fort Chaffee, Arkansas loading site enroute to Camp Grayling, Michigan for their annual training. The military tow travelled the McClellan Kerr Arkansas River system to the Mississippi River, then moved upstream to the Illinois Waterway and Chicago, Illinois. From Chicago, the tow crossed Lake Michigan to the unloading site at Frankfort Harbor, Michigan. From there, the convoy road marched to the training area at Camp Grayling, Michigan. After completing its annual exercise, the convoy road marched from Camp Grayling to Rock Island, Illinois. At Rock Island, the Guard used an USACE loading site on the Mississippi River to load their equipment on barges for the trip downstream to Fort Chaffee, Arkansas. [Ref.39:p.4]

The upstream movement covered 1,450 miles. The tow travelled on four waterways at an average speed of about six miles per hour. The cargo moved downstream at an average speed of seven miles per hour. [Ref.39:pp.5-6]

a. ARARNG Equipment Load Manifest

The move totaled 162 pieces of equipment including:

12 M110A2 8-inch self-propelled howitzers. [Ref.48:p.1]

b. Unit Move Analysis

The ARARNG reviewed four modes of transportation for the mobilization exercise: air, truck, rail, and barge.

(1) Air Movement. Air movement was the preferred choice to support training requirements. The exercise would have required more than 30 C-5A aircraft because of the Guard's outsized equipment. The C-5A aircraft were not available to the Guard due to other Military Airlift Command missions. Estimated cost of a C-5A operation was in the millions of dollars. [Ref.39:p.7]

(2) Road March. The ARARNG officials dropped the idea of a road march from consideration because of two factors. Since the road march required four days each way, movement by convoy would put the actual training time below the minimum requirement of nine days in the field. Additionally, road marches of this distance, over the highways, present safety risks to the public. Road marches also create excessive wear on the equipment. [Ref.39:p.7]

(3) Rail Movement. To move the equipment by rail would require 82 cars. Based on previous moves, the ARARNG estimated $4,000 to $6,000 per car. [Ref.39:p.7]

(4) Barge Movement. Barge movement was chosen because it met both the training requirements and provided the maximum cost savings.

Table 12 shows the details of the cost comparisons between rail and barge movement. [Ref.39:p.7]

TABLE 12

ARARNG MOVEMENT (1987) COST COMPARISON

Rail Cost Estimate	
Cost of Rail Cars (82 at $4,020 each)	$329,600
Manpower to Load	2,000
Tie-down Teams	20,000
Tie-down Material	60,000
Total Railroad Cost Estimate	$411,600
Barge Cost Estimate	
Cost of Barges and Towboat (actual contract price)	$212,000
Manpower to load in 8 hours	2,000
Tie-down Teams	10,000
Tie-down Material	30,000
Road March	22,000
Total Barge Movement Cost Estimate	$276,000
Cost Savings	
Rail Cost	$411,600
Barge Cost	276,000
Total Savings	$135,600

Source: [Ref.39:p.7]

"The event was the largest movement of military equipment using inland waterways since the 1940s." [Ref.49:pp.24-25] The movement proved the ability of the inland waterways to move battalion-sized organizations while maintaining unit integrity. The event also marked the first time the military used a commercial towing firm. It was the first contract of this type awarded by the Military Transportation Management Command (MTMC). The Canal Barge Company won the award and moved the ARARNG unit's 1,411 tons of equipment. [Ref.50]

4. 101st Airborne Division Movement 1989

In August and September 1989, the Second Brigade, 101st Airborne Division (Air Assault) moved 670 pieces from its base at Fort Campbell, Kentucky to the Joint Readiness Training Center (JRTC) at Fort Chaffee, Arkansas.

On 28 August, two 4,200 horsepower Canal Barge Company towboats, the Elizabeth Ann and Walter Hagestad, pushed 42 barges into position for loading. The loading site chosen was Lock "C" on the Cumberland River, ten miles from Fort Campbell, Kentucky. On 30 August, military personnel completed loading the 42 barges. In only 14 hours, soldiers had loaded 688 vehicles, two helicopters, and related equipment. The tows departed one full day ahead of schedule and arrived at Fort Smith, Arkansas on 6 September, 1989. The Walter Hagestad pushed her tow of 19 barges to the off-loading site at Fort Chaffee, Arkansas, while the Elizabeth Ann continued to Camp Gruber, Oklahoma with the remaining barges and arrived at the Camp Gruber off-loading site the following day. The 101st Airborne movement covered 829 river miles over the Cumberland, Tennessee, Ohio, Mississippi, and Arkansas Rivers. [Ref.51]

On 24 September, after completing the exercises, the 101st personnel loaded vehicles, helicopters, and equipment on to the same barges for the return trip. [Ref.51:pp.14-17]

a. 101st Airborne Equipment Load Manifest

The move totaled 693 pieces of equipment including:

1. 688 Vehicles

2. two UH-60 Black Hawk Helicopters [Ref.51:p.17]

b. Unit Movement Analysis

The 101st Airborne division (Air Assault) moved to Fort Chaffee, Arkansas and Camp Gruber, Oklahoma for a JRTC exercise. This move surpassed, in size, all previous barge movements. The two tows moved 628 vehicles, two UH-60 Blackhawk helicopters, and related equipment, 1,772 miles round trip. [Ref.51:pp.14-17] The units 4,000 tons of equipment moved on 42 barges. This was the first mobilization by waterborne transportation of an active Army unit since World War II. [Ref.52:pp.5-12]

Another first occurred when members of the Sixth Battalion, 101st Aviation Regiment, landed two UH-60 Blackhawk helicopters directly onto the deck barges. Soldiers secured the two helicopters in full flight configuration for the trip. Upon arrival at the training exercise destination, unit pilots flew the helicopters off the barges. [Ref.53:pp.4-5]

The following two tables (Table 13, Table 14) compare the cost of the 101st movement using two modes of travel: barge and rail. Historically, the 101st has always used rail to transport a unit of this size. The two cost analysis studies were done independently. The major difference between the studies appears in the helicopter cost. The analysis shown in Table 14 does not reflect the cost incurred to fly the helicopters to their destinations and return flight.

TABLE 13

101ST MOVEMENT (1989) COST COMPARISON

Barge Contract	$ 743,000
Labor Cost	14,740
Total Barge Cost	$ 757,740
Rail Contract	$ 749,000
Labor Cost	94,370
Necessary Line Haul	174,200
Helicopter Travel	50,400
Locomotive Service	81,840
Total Rail Cost	$1,069,810
Total Barge Cost	757,740
Total Savings	$ 312,070

Source: [Ref.54]

TABLE 14

101ST MOVEMENT (1989) COST COMPARISON

Rail Contract	$ 927,365
Labor	79,408
Total Rail Cost	$1,006,773
Barge Contract	$ 696,150
Labor	36,307
Total Barge Cost	$ 732,457
Total Rail Cost	$1,006,773
Total Barge Cost	732,457
Total Savings	$ 274,316

Source: [Ref.55]

5. 101st Airborne Division Movement 1990

On 15 January, 1990, the 20th Engineer Battalion (Combat) B Company, 101st Airborne Division (Air Assault) began 'Screaming Beast 90'. This exercise required the deployment of 112 pieces of equipment from Fort Campbell, Kentucky to the nation of Belize, Central America.

Soldiers loaded the unit's equipment on one ocean-going barge located at lock "C" on the Cumberland River. On 18 January, 1990, the Compass Freedom with tow departed down the Cumberland River to the Tennessee River and onto the Tennessee-Tombigbee Waterway. The tow arrived at the Port of Mobile, Alabama, on 21 January, 1990. At the port, the ocean-going towboat, Betty G. relieved the river towboat. [Ref.56]

On 23 January, the tow left the Port of Mobile, Alabama for the transit across the Gulf of Mexico, about 1,400 nautical miles. During the Gulf crossing, the Betty G. towed the barge using about 1,700 of cable to maintain control of the tow. [Ref.56]

> "Averaging 8 to 8 1/2 knots across the Gulf, the tow boat was required to slow down to 4 to 4 1/2 knots in order to not arrive at the port in Belize prior to their scheduled clearance date of 30 January 90." [Ref.56]

The tow arrived at the Belize port on 30 January, 1990, after completing a 2,000 mile journey. Off-loading of equipment was complete by 1 February, 1990. [Ref.56]

a. Unit Move Analysis

The decision by the 101st Airborne Division to use an alternative transportation mode provided the following results:

1. The onload allowed a variety of Army units to practice their operational skills. The 372nd Transportation Company (Terminal Transport) conducted the actual loading operations at Lock "C" on the Cumberland River. The unimproved loading site is about ten miles from Fort Campbell. The 41st Medium Girder Bridge Company made a drive-on ramp by constructing a bridge from the lock wall to the barge. Members of the 326th Medical Battalion manned an aid station and the Law Enforcement Command provided traffic control. A United States Coast Guard boat patrolled the river during loading operations. [Ref.56]

2. The 101st Airborne Division (Air Assault) can deploy outside the Continental United States using ocean-going barges. "The unit deployed on one class 260 ocean-going barge, 260 ft x 72 ft." [Ref.56] The actual loading began on 15 January when forklifts started shuttle-loading 40 CONEX containers along with lumber, fuel, and repair parts. On 16 January, the unit drove on the rolling stock, 41 vehicles, and 29 trailers. To complete the onload, a crane lifted two mission required pallets of bridging sections. Total loading time for the two days was about 12 hours. The contractor used the following day to tarp and tie down the load.

The draft of the loaded barge was only four and one-half feet. The cargo traveled the Cumberland River, Tennessee River, and Tennessee-Tombigbee Waterway on its way to Mobile, Alabama. The depth of those waterways average nine to twelve feet year-round. Coordinated efforts from the USACE provided priority lockage for the military tow.

The 101st placed three military supercargo onboard to accompany the tow to Belize. The barge arrived at Belize on 30 January 1990. Docking occurred on 31 January and off-loading of equipment began at 1400 hours. Personnel offloaded the CONEX containers in one hour and completed all off-loading on 1 February. [Ref.56]

There was no reported damage to the equipment and receiving personnel noted that there was no salt from ocean spray apparent on any of the equipment. All vehicles were in good mechanical condition and were able to self-deploy off the barge. [Ref.56]

D. CRITERIA FOR TRANSPORT MODE SELECTION

The Military Traffic Management Command (MTMC) is completely familiar with air, rail, and ground transportation. However, MTMC has limited knowledge on how to use the inland waterways for transportation. MTMC has had to respond to the recent interest in inland waterway unit moves on a case-by-case basis. [Ref.5:p.10]

The following mode selection guidance from MTMC reflects this lack of inland navigation experience. The MTMC Engineering Agency (MTMCTEA) Pamphlet 700-2, LOGISTICS HANDBOOK FOR STRATEGIC MOBILITY PLANNING, provides only the following general guidance concerning mode selection for CONUS unit equipment moves:

1. Mode selection should consider economic requirements, availability of assets, hostile threat assessment, and any special requirements.
2. Transportation options include motor, rail, and inland waterways. MTMC identifies inland waterways as an option for equipment that exceeds commercial motor or rail carrier capabilities.

Guidance for the use of commercial transportation of unit equipment includes:

1. Army units will use commercial transportation modes during mobilization
2. Sufficient commercial resources must be available to support the move and meet the Required Delivery Date (RDD)
3. MTMC must validate the commercial movement capability. The major command (MACOM) must approve the move.

Policy exceptions include:

1. Organic over-the-road marches are authorized when units are located within a one day march to the mobilization station. The unit commander must determine that support enroute is adequate, and that the move will not adversely affect unit equipment.

2. Organic over-the-road marches are authorized for movements greater than the distance covered in a 24 hour period when commercial transportation is not adequate.

E. TRANSPORTATION MODES

1. Motor Transport

Motor transport is often required for at least some cargo movement in any mobilization. [Ref.57:p.13] However, oversized and overweight equipment are the primary restrictions for movement of units during mobilization by motor transport. The interstate system has legal limits of 80,000 pounds for gross vehicle weight, 8 1/2 feet for width and 13 1/2 feet for height. The legal limits on secondary roads are often even more restrictive. Compared to these limits more than 25 Army equipment-transporter combinations exceed the legal weight and size limits of the nation's highways. For example, the M1 Abrams tank transported on the M746-M747 heavy equipment transporter (HET) has a gross vehicle weight of about 200,000 pounds. Successful highway movement of heavy equipment requires extensive planning and coordination to prevent lost time during mobilization and damage to highways and vehicles. [Ref.58:p.8]

Key factors influencing movement of heavy equipment by motor transport include:

1. Civil highway authorities will only permit oversized and overweight defense moves when there is a clear national defense need or emergency. [Ref.58:p.10]

2. Vertical clearance and bridge capacity are the two most critical factors restricting highway movement of heavy equipment. Bridge restrictions often include: maximum speed of 5 miles per hour, movement only along the center line, prohibition of opposing traffic, and spacing between vehicles of at least 100 feet.

   Large safety factors are routinely applied to bridge carrying capacities. Bridge analysis techniques to determine structural load capacity prior to convoy loadings are time-consuming. The difficult analyses are often imprecise because of the deteriorating effects of age and the inability to determine past loading. [Ref.58:p.10]

3. The shortest route from origin to destination is not always the best route for moving overweight and oversized equipment. [Ref.58:p.10]

In part, for these reasons, organizations will usually deploy overweight and oversized equipment by rail. Table 15 lists the motor transporter requirements for all-motor movements.

2. Railroads

At present, rail equipment is the primary means of transport for mobilization and deployment of active CONUS based forces.

> "The railroad system, unlike motor, air, or water transport, provides a truly nation wide network of service." [Ref.34:p.96]

This 'network of service' allows the industry to support any type and quantity of military commodity. This flexibility is furnished by the large carrying capacity and variety of car types. [Ref.34:p.96] Due to the nature and time sensitivity of deployment and mobilization requirements, railroads will, within the foreseeable future, continue to

TABLE 15
UNIT CONVOY AND MOTOR TRANSPORTER REQUIREMENTS
FOR AN ALL-MOTOR MOVEMENT

	Semitrailers				
	40-Foot Flatbeds	HETS	Total	Containers a/	Residuals b/
Heavy Division	3,603	1,376	4,979	307	129,036 c/
Heavy Division (Mechanized)	3,663	1,352	5,015	307	129,036 c/
Infantry Division	3,495	541	4,036	255	129,816 c/
Light Infantry Division	1,404	17	1,421	172	32,345 d/
Airborne Division	1,966	19	1,985	272	33,983 e/
Air Assault Division	2,700	15	2,715	380	31,877 f/
Aviation Brigade (Separate)	912	0	912	132	31,538 g/

NOTES:

Nonorganic assets (military or commercial) were used to move all of the unit's equipment.

a/ Unit container requirements were generated for nonvehicular dimensionally compatible equipment. Containers were then loaded onto 40-ft flatbeds.

b/ Equipment left over after loading all motor transporters. Residuals were due to oversize, overweight, or both (See c/ through g/ below.)

c/ Residuals consist of 16 bridges, ARM VEH LCH, Class 60, 403" x 162" x 70", 29,300 lb.; 7 ramps, load veh, 431"x104"x44", 5,100 lb; 1 M270A1 lowbed trailer; 3 M870 40-ton trailers; and 24 M747 trailers. (Infantry division has 6 M747 trailers as residuals.)

d/ Residuals consist of 2 ramps, load veh, and 6 M870 40-ton trailers.

e/ Residuals consist of 2 ramps, load veh, and 1 M270A1 trailer.

f/ Residuals consist of 6 ramps, load veh, and 2 M270A1 trailers.

g/ Residual consists of 1 M270A1 trailer.

Based on J-series TOE as of November 1988

Source: [Ref.57:p.16]

serve as the primary transportation mode. [Ref.4:p.18] For example, heavy duty fleet cars are the primary means of transporting the Army's main battle tanks. Table 16 provides the rail loading requirements for six different types of Army divisions.

3. Barges

Until recent years, the military did not consider the inland waterway system as a mobilization transportation mode for unit movements. Starting in 1986, actual waterway movements by large units of active Army and the Army National Guard have demonstrated that cost savings are available. However, significant cost savings occur only when unit movements meet the following criteria:

1. When a requirement exists to transport a significant volume of heavy and outsized equipment.
2. When the point of origination and the point of final destination are both within a reasonable distance of the inland waterway system. Figure 4 identifies the approximately 78 major military installations that are accessible by the inland waterways.

F. BARGE FACTORS INFLUENCING UNIT MOVEMENTS

1. Less Energy Required

In comparison with all other modes of transport, water transportation requires less energy for each ton moved over each mile. Barge transportation can be two and one-half times more energy efficient than the railroads. On the lower Mississippi River, a single 5,000 horsepower towboat often pushes a 40 barge tow. This 40 barge tow may be

TABLE 16
RAIL LOADING REQUIREMENTS FOR ARMY
TYPE DIVISIONS AND A SEPARATE AVIATION BRIGADE

	89-Foot Flatcar	60-Foot Flatcar	68-Foot DODX Flatcar	Total Railcars	Containers (20-ft)	Total Weight	
						STON	MTON
Heavy Division	1,130	1,115	254	2,499	307	82,650.4	253,415.3
Heavy Division (Mechanized)	1,131	1,166	225	2,522	307	80,602.3	253,116.5
Infantry Division	1,161	827	107	2,095	255	47,655.8	188,952.4
Light Infantry Division	521	215	0	736	172	11,445.2	61,847.2
Airborne Division	798	177	0	975	272	14,534.5	78,018.8
Air Assault Division	1,018	368	0	1,386	380	23,653.0	137,711.9
Aviation Brigade (Separate)	312	163	0	475	132	9,519.8	75,564.0

NOTE: Unit container requirements were generated for nonvehicular dimensionally compatible equipment and loaded onto flatcars. As of November 1988

Source: [Ref.57:p.25]

Figure 4 Military Installations Accessible by the Inland Waterways

Source: [Ref.4]

more than one-fourth mile in length and 200 feet wide and can have the carrying capacity equal to 16 100-car freight trains. [Ref.28]

2. Modal Competition

Use of the barge industry generates competition among rail, truck, and water carriers that results in reduced freight rates. [Ref.59:p.2]

3. Shipment Preparation

On deck barges, personnel do not have to block, brace, and tie-down each vehicle. Only the first and last rows of vehicles on the entire tow are secured. [Ref.51:p.14] Estimates based on actual movements project a savings of more than 60 percent over rail cost for tie-down and bracing material. [Ref.39:p.7]

4. Loading Times

Equipment can be on-loaded or off-loaded with a minimum of personnel. Most of the recent moves have been from unimproved sites. Vehicles can be driven on and off even at these sites. Units can load equipment and vehicles ready for deployment at destination. [Ref.60] This characteristic eliminates the requirement for decubing procedures, which are labor and time intensive. MTMC recommends one hour goals for decubing, although varying situations often cause decubing to take longer than an hour. For example:

> To decube a vehicle cab, lower the cab top, leaving the canvas threaded through the top windshield canvas channel. Wrap the canvas around the windshield and then recline it into its lowered position. [Ref.61:p.4]

Experience shows a 45-50 percent reduction in loading times for barges compared to other modes. [Ref.60] Barges can transport vehicles with full fuel tanks, including tankers. This capability eliminates a major logistic problem of getting fuel at the destination site.

5. Size Capability

There is minimal restriction on width, height, or weight of load. Barges can move heavy, large, and awkward items that do not fit on truck or rail transportation [Ref.61:p.5]. Fifteen M35 1 1/2 ton trucks loaded on a 120 feet by 30 feet river deck barge uses only 23 percent of the barge's total tonnage capacity. [Ref.63] Vehicles, including battle tanks, will exceed the deck loading space before reaching the barge's tonnage capacity. The smooth, steady ride of barge transport allows activities to move aircraft in full flight configuration. For fixed wing aircraft, like the B-52 with its 185-foot wingspan, water movement is the only non-flight choice. [Ref.62:p.5]

6. Security

The characteristics of waterborne movement increases the security of the equipment. Military tows are underway 24 hours a day and manned constantly. The troops that travel on board (supercargo) not only provide security but also perform light maintenance on the equipment. [Ref.40]

> In all the unit barge moves to date, there have been no instances of theft, damage, or vandalism on a barge move. To preclude vandalism, theft, or damage on rail and truck shipments, special precautions must be taken, including tarping, blocking, bracing and tiedowns, sealing doors, covering windshields, etc. Other than to tie down the first and last rows of vehicles, there is no need to do the same on inland waterway barge shipments since the mode provides a natural barrier to such threats. [Ref.4:p.13]

7. Location Monitoring

Ship to shore communication over the USACE network allows for continuous communication. The ability to monitor constantly the location and status of unit movements is of principal importance during mobilization. [Ref.64:p.2]

8. Total Shipment Time

Total lapsed-time for barge movement can be equal to or less than total lapsed-time by truck or rail mode. [Ref.60] A study was done comparing a hypothetical movement of a howitzer battalion from Tulsa, Oklahoma to New Orleans, Louisiana. The study compared the transit times, between water and rail, consisting of 141 pieces of equipment. Table 17 provides the breakdown of the estimated lapsed time. The larger the size of the movement, the more time competitive becomes the barge movement. The actual off-loading time for 688 vehicles on a barge move was seven hours and 25 minutes. The estimated off-load for a rail operation of the same size was 36 hours. [Ref.60] Table 18 provides average rail car loading times.

G. SUMMARY

Actual waterway movements by both the Army National Guard and active Army units realized significant savings when the unit movement met two criteria. One, the unit moved quantities of heavy and outsized equipment. Second, the waterborne movement started and ended at military installations near the waterways.

TABLE 17

COMPARISON OF TRANSIT TIMES FOR RAIL AND BARGE

Barge Movement		Rail Movement	
9	standard deck barges	70	rail cars
.5	day on-loading time	3	days on-loading time
4.5	days transit time	3	days transit time
.5	day off-loading	1.5	days off-loading
5.5	Total Days	7.5	Total Days

Source: [Ref.38]

This conclusion is not surprising. In fact, it is consistent with the service characteristics of water transportation. Water carriage provides low cost service when shippers move bulk commodities in volume between limited origins and destinations [Ref.34:p.394].

The Guard units originally made the test movements to confirm cost savings. However, after accomplishing a series of unit moves by water, the military discovered another major benefit. For both the Army National Guard and the active Army, waterborne movement provided the additional benefit of training. Their military personnel received training on a new transportation mode for deployment and mobilization.

TABLE 18
AVERAGE RAILCAR LOADING TIMES

Type of Railcar	Number Loaded	Type of Load	Manpower	Time (Hr)
54-Ft Flatcar 1/	10	2-1/2-Ton Trucks (2 per Railcar) 1/4-Ton Trailers, Wreckers, Mules, Forklifts, Jeeps, CONEXes	10 per railcar	8.25
54-Ft Flatcar 2/	9	1/4-Ton Trailers and Containers	10 per railcar	8.2
60-Ft Flatcar 1/	11	2-1/2-Ton Trucks (2 per Railcar)	10 per railcar	5.1
60-Ft Flatcar 2/	10	Semitrailers (5 per Railcar)	10 per railcar	8.3
89-Ft Bilevel 1/	15	Jeeps, 3/4-Ton Trucks, Gamma Goats (Total 340 Vehicles)	2 per vehicle	9.1
89-Ft TOFC 3/	12	Semitrailers with MILVANs and Containers on Board	8	4.0

NOTES: 1/ Loaded using end ramps and vehicle's own power.
2/ Loaded using forklifts/rough terrain forklifts.
3/ Trailer on flatcar. Loaded using end ramps. Tractors used to drive on trailers.

Source: [Ref.57:p.27]

V. SUMMARY AND CONCLUSIONS

A. SUMMARY

This thesis addressed those aspects of the inland waterways navigation system which could influence the Department of Defense's (DOD) ability to deploy and sustain military forces worldwide. A brief summary of the major chapters follows:

1. Chapter II - History of the Inland Waterways System

The chapter surveyed the traffic that has moved over the inland waterways. It also reviewed the role of the inland waterways in the nation's economic and military development. The chapter examined three periods in the development of the inland waterways. The first period documented the use of rivers in their natural state and the emergence of economic conditions that led to the canal building era. The Civil War ended this period. The second period lasted about thirty years after the Civil War. During this period, the railroads developed into a strong domestic transportation mode while the inland waterways entered a period of neglect. The third period recorded the industry's development from the last decade of the 19th century up to the present. The emphasis of this period was on the contributions of inland navigation to victory efforts during both World Wars. The purpose of the historical review was to provide a foundation for the following chapters which explored the military potential of inland navigation.

2. **Chapter III - The Present Inland Waterways Industry**

The focus of this chapter was on the adequacy of the inland waterway industry to support national mobilization. The chapter identified the bulk commodity groups, such as petroleum and coal ore, that offer the most advantage for waterborne movement. Additionally, the chapter described the principal inland waterway systems including: the New York State Barge Canal, the Atlantic Intracoastal Waterways System, the Mississippi River System, the Gulf Intracoastal Waterways System, and the Pacific Coast Waterways System. The chapter also reviewed the status of the physical equipment and facilities on the inland waterways including locks and dams, inland ports, and the towboat and barge industry. In addition, the chapter discussed the influence of the United States Army Corps of Engineers on the development and management of the inland waterways navigation system. The final section of the chapter explored the ability of the inland waterways industry to support national mobilization efforts.

3. **Chapter IV - Current Military Use of the Inland Waterways**

This chapter reviewed the military's current use of the inland waterways by:

1. Providing a brief chronology of current military shipments on the inland waterways

2. Reviewing four key military movements on the inland waterways

3. Comparing the various transportation modes used for military movement

4. Identifying the advantages of using inland navigation for military unit movements

In recent years, Army units have made a variety of successful waterborne movements. These dollar-saving moves have occurred at a time of reduced defense budgets. Also, during this period, DOD directives have tasked military commanders to better manage their dwindling resources, including transportation dollars. Transportation costs for moving equipment can make up a large part of an organization's operating budget.

Lessons learned from these test movements have provided new information about the potential for increased military use of the inland waterways. Inland waterway movement of unit equipment provides substantial cost savings with the additional benefit of training. Using waterborne movement allows military personnel to receive training on an alternative transportation mode for deployment and mobilization.

B. MOBILIZATION

One accepted definition of mobilization is the swift, broad, real-time reallocation of military and non-military resources to meet a politico-military challenge. [Ref.65:p.14] Mobilization involves four distinct phases. Phase one is the movement of existing war-fighting equipment. [Ref.4:p.13] This phase is the most time critical. Currently, there is no mobilization plan that includes the use of the inland waterways during contingency operations. [Ref.23:p.1]

Phase two is sustainment. This involves the movement of large quantities of war-fighting material such as fuel, ammunition, repair parts, and subsistence. Barge movements of these cargos of ammunition,

fuel, and foodstuffs are unlikely due to small individual shipment quantities. [Ref.4:p.13]

Phase three is economic sustainment. This is the movement of large amounts of bulk raw materials required to sustain the nation's industrial base. [Ref.4:p.14] Examining the acceleration that occurred during World War II showed that traffic of bulk raw commodities on inland waterways increased by 26 percent. [Ref.23:p.13] Today, the inland waterway industry has the slack capacity to support similar increases in bulk material movements during mobilization.

Phase four is the return of equipment from overseas after the conflict. [Ref.4:p.14] This movement is not time sensitive. Therefore, cost effectiveness considerations should influence decisions on transportation modes used during this phase, such as low-cost barge transport. Water transport cost can be lower than the costs of any other form of transportation. Actual waterway movements by Army units have shown that considerable savings in transportation dollars are possible. [Ref.4:pp.14-15]

C. CONCLUSIONS

In the past five years, military unit movements have proved that the inland waterway system is a valid alternative mode of transportation. This thesis has charted the dramatic growth in the use of the inland waterways for these unit movements. With prior planning, military units returning from overseas deployment can benefit from the cost savings available in using inland waterway transportation.

Returning military units often have significant volumes of heavy equipment. This requirement to move a quantity of heavy equipment meets one of the two primary criteria for selecting barge transport. By designating Gulf Coast ports as points of entry for returning units, DOD planners can meet most of the second criterion for using inland navigation. This second criterion is the need for origination and destination points to be within a reasonable distance of the inland waterway. The Gulf Intracoastal Waterways System and the Mississippi River System connect Gulf Coast ports with 15 states located along the Mississippi, Missouri, Ohio, Illinois, and Tennessee rivers, and the Gulf of Mexico. [Ref.66] Using Gulf Coast ports as points of entry minimizes the handling of unit equipment. The Gulf Coast facilities can rapidly transform shiploads of unit equipment into barge-loads using Roll-On/Roll-Off (RO/RO) docks. The Gulf Coast ports shown in Table 19 are RO/RO capable. They allow the inland navigation system to exploit one of the advantages of barge transport which is rapid loading with minimum personnel.

From Gulf Coast ports, industry towboats can provide low cost transport to military installations located near the inland navigation system. Midwestern military installations that do not have direct access to the inland waterways can still benefit from low-cost barge transportation. These installations can take advantage of a distribution channel designed to provide service to the middle half of the nation. This channel is composed of the port of New Orleans, the Mississippi River, and the ports of Southwestern Illinois at St. Louis. [Ref.66] The Gulf Intracoastal Waterways System provides Gulf Coast ports with direct

connection to this distribution channel. [Ref.66] The ports at St. Louis are the most northerly ice-free river terminals on the Mississippi River system. They can provide year-round operational capability for the military. The second largest rail center in the United States is also located in the St. Louis area. [Ref.66] Thirteen trunk line railroads operate 28 rail-lines radiating from St. Louis. From there, rail transport can move unit equipment to most midwestern military installations within two days. Figure 5 shows rail transit times.

TABLE 19

GULF COAST PORT BERTHING CAPABILITY

Port	RO/RO
Tampa, FL	1
Pensacola, FL	2
Mobile, AL	1
New Orleans, LA	4
Baton Rouge, LA	1
Lake Charles, LA	3
Beaumont, TX	2
Port Arthur, TX	1
Houston, TX	4
Galveston, TX	2
Corpus Christi, TX	7

Note: All berths have a minimum 20-foot draft.

Source: [Ref.57:pp.49-50]

Unit equipment loaded on barges at Gulf Coast ports of entry can reach midwest Army installations in less than ten days transit time. For example, barge transit time from the port of New Orleans to St. Louis is

Figure 5 Rail Transit Times

Source: [Ref.66]

five days. Moving unit equipment by rail from the St. Louis area to most midwestern installations requires one to two transit days.

This thesis has tried to extend the general knowledge of the potential for military unit movements on the inland waterways. Further research should concentrate on expanding the inland waterways data base. This could be accomplished by government and industry sharing requirements and knowledge specific to waterborne movements. This information is needed for cost comparisons of inland navigation in relation to other transportation modes. Similar research should also be undertaken concerning how to include the inland navigation system in long-range strategic planning for returning overseas deployed units.

LIST OF REFERENCES

1. Sampson, R. J. and Farris, M. T. Domestic Transportation, 2nd ed., Houghton Mifflin Company, 1971.

2. Association of the United States Army Special Report, Strategic Mobility - Can We Get There From Here - In Time?, 1984.

3. Robinson, M.C., "Mobilizing the Waterways", Undated.

4. Military Traffic Management Command, Inland Traffic Directorate, Military Utilization of the Inland Navigation System, by C.T. Angelo and others, August 1990.

5. Military Traffic Management Command, Inland Traffic Directorate, Movement of Military Units - The Option of the Inland Waterway Navigation System, by J.R. Henderson, 18 August 1988.

6. Howe, C.W. and others, Inland Waterway Transportation, John Hopkins Press, 1969.

7. Hindley, G., A History of Roads, The Chaucer Press, Ltd., England, 1971.

8. Morris, J.M., Our Maritime Heritage, University Press of America, 1979.

9. Goodrich, C. and others, Canals and American Economic Development, Columbia University Press, 1961.

10. Hunter, L.C., Steamboats on the Western Rivers, Harvard University Press, 1949.

11. Stover, J.F., American Railroads, The University of Chicago Press, 1961.

12. Drago, H.S., The Steamboaters, Dodd, Mead, and Company, 1967.

13. Havighurst, W., Voices on the River, Macmillan Company, 1964.

14. Lavelle, J.F., "Port of St. Louis, The Midwest's Outlet to the World," paper presented to the Scott-St. Louis Chapter of the National Defense Transportation Association Chapter. 16 February 1990.

15. Haefner, L.E., Introduction to Transportation Systems, Holt, Rinehart, and Winston, 1986.

16. The American Waterways Operators, Inc., Some Facts You Should Know From America's Inland and Coastal Barges and Towing Industry, Undated.

17. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Part 5, 1965.

18. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Part 5, 1974.

19. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Part 5, 1984.

20. Cook, P.D., "An Approach to the Analysis of Multi-Purpose Water Use Impacts of Commercial Navigation on the U.S. Waterway System," Proceedings - Transportation Research Forum, v. 20,n. 1, 1979.

21. American Waterways Operators, Inc., Waterways of the United States, 1981.

22. Cook, P.D., Roark, P., and McGaw,D.C., "Water Flow, Light Loading, and Transport Costs on the Missouri, Apalachicola, and Alabama Rivers." Proceedings - Transportation Research Forum, v.21, n.1, 1980.

23. Eighty-sixth Congress, Special subcommittee of the committee on Armed Services House of Representatives, Adequacy of Transportation systems in Support of the National Defense Effort in Event of Mobilization, Government Printing Office, Washington, D.C., October 1959.

24. Concord Reference Books, Inc., The New American Desk Encyclopedia, 1989.

25. Military Traffic Management Command, Transportation Engineering Agency, Analysis of Conus Inland Waterways for National Defense, 1978.

26. The American Waterways Operators, Inc., The Barge and Towing Industry, Undated.

27. "T.L. James Accepts Towboats," The Waterways Journal, September 2, 1991.

28. The American Waterways Operators, Inc., We Can Move Mountains, Some Facts About the Nation's Tug and Barge Industry, Undated.

29. Bronzini, M.S., "Analytical Model of Operations at Inland River Ports and Terminals," Proceedings - Transportation Research Forum, v.23, n.1, 1982.

30. Tri-City Regional Port District, "Tri-City Regional Port District," Granite City, Illinois, Undated pamphlet.

31. Bastian, D.S., "Lock Capacity as a Function of Tow Size," Proceedings - Transportation Research Forum, v.25, n.1, 1984.

32. Baldwin, P., Lane, L.L., and McNamara, T.M., "Congestion and Congestion Tolls on the Inland Waterways," Proceedings - Transportation Research Forum, v.25, n.1, 1983.

33. Reiter, S., "Inland Waterways," Workboat Magazine, July/August 1991.

34. Coyle, J.J., Bardi, E.J., and Cavinato, J.L., Transportation, 3rd ed.,West Publishing Company, 1990.

35. Evans, B., " Black Warrior-Tombigbee's Oliver Lock Dedicated, The Waterways Journal, August 26, 1991.

36. Allman, W.P., "Determining Barge and Towboat Requirements for Simple Waterboat Movements," Transportation Journal, Fall 1982.

37. Spaul, P.J., "Reviving Inland-Waterways Transport," Army Logistician, March/April 1987.

38. United States Army Corps of Engineers (USACE), Tulsa District, Military Use of the Inland Waterways by J.W. Leggett, October 1986.

39. USACE, Tulsa District, Military Waterborne Movement Summer 1987, September 1987.

40. USACE, Tulsa District, Memorandum for the Record, Subject: National Guard Activity on the McClellan-Kerr Update, (U), 9 May 1988.

41. "Port of Catoosa Transport Saves Military Money," Tulsa Tribune, April 15, 1989.

42. USACE, Tulsa District, Fact Sheet: Unit Movements - Current Experience, Military Use of Inland Waterways 1986-1989, Undated.

43. "Historic Shipment Utilizes Tenn-Tom," The Waterways Journal, January 29, 1990.

44. "Army Cargo Hits the Rivers," The Waterways Journal, October 7, 1991.

45. USACE, Tulsa District, "Report on OKARNG-USACE Test Movement, McClellan-Kerr Arkansas River Waterway, 9-10 April and 17-18 April 1986," 23 April 1986.

46. USACE, Tulsa District, "Test Movement, OKARNG-USACE McClellan-Kerr Arkansas River Waterway, 9-10 April and 17-18 April 1986, Transportation Cost Analysis," 12 May 1986.

47. USACE, Tulsa District, Memorandum for the Record, Subject: Contact with Texas Army National Guard (TXARNG) - Enroute to Fort Chaffee via Waterway, (U) 12 May 1986.

48. USACE, Detroit District, After Action Report - Unloading of the Arkansas National Guard Howitzer (SP) Battalion at Frankfort Harbor, July 1987.

49. Spaul, P.J., "Inland Waterways," Soldiers, April 1988.

50. Military Department of Arkansas, News Fact Sheet: Inland Waterways Movement, 1-142 FA, 7 June 1987.

51. Wollenberg, R.F.,Ferguson, W.H., "Inland Waterways Deployment Alternative," Army Logistician, July/August 1990.

52. Yates, J.L., "Water Move by Active Unit 1st Since WWII," The Waterways Journal, September 11, 1989.

53. Anderson, S., "Screaming Eagles Float on Inland Waterways," USACE, Southwestern Division, Pacesetter, October 1989.

54. USACE, Nashville District, Fort Campbell Military Movement, August 1989 Cost Analysis by Phillip Jones, Undated.

55. Tennessee Valley Authority, Transportation Rate Analysis McClellan-Kerr Navigation System Study, October 11, 1989.

56. Ferguson, W.H., Installation Transportation Officer Fort Campbell, Kentucky, Memorandum for Director of Logistic SW, Subject: After Action Report - Screaming Beast 90, 9 February 1990.

57. Military Traffic Management Command Engineering Pamphlet 700-2, Logistics Handbook for Strategic Mobility Planning, August 1989.

58. Aiken, L.E., "Highway Deployment," Army Logistician, May-June 1987.

59. The American Waterways Operators, Multiple Choice - All of the Above, Undated.

60. Fort Campbell, Kentucky, After Action Report, Subject: Deployment of the Second Brigade by Barge - August/September 1989, Undated.

61. Maughn, W.T., "Readying Equipment for Deployment," Army Logistician, May/June 1987.

62. "Lots of Things can Move Better by Barge," The Waterways Journal, December 30, 1985.

63. Canal Barge Company, Inc., New Orleans, Louisiana, 120 Ft. Deck Barge Configuration Detailing, Undated.

64. Unit Movement Coordinator Training Course, Fifth Army, Military Utilization of Inland Waterways, October 1988.

65. Pfaltzgraff, R.L., Ra'anan, U., The Defense Mobilization Infrastructure, Archon Books, 1983.

66. The Transportation and Distribution Assets of Greater Southwestern Illinois Pamphlet, Waterways-Rail-Middle Coast Access Fact Sheets, Undated.

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